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COMPLETE SPECIFICATION

DRAWINGS ATTACHED p.2 - Soot burns off

Method Of And Apparatus For Catalytically Filtering and Cleaning Exhaust Gases From Internal Combustion Engines

We, AUTOMOBILES M. BERLIET, a Joint Stock Company organised and existing under the laws of France, of 241 Avenue Berthelot, Lyon, France, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention is concerned with the filtering and purifying of internal combustion engine exhaust gases containing solid ingredients.

Exhaust gases evolved in the combustion of some fuels, such as the exhaust gases of Diesel engines, contain—in addition to very small quantities of gaseous combustion products, such as oxides of carbon, oxides of nitrogen, aldehydes and organic acids—solid ingredients, chief amongst which is soot, particularly where large quantities of fuel are injected and the engine operates under heavy load. The soot, which is evolved in the cracking of the fuel hydrocarbons, consists of very fine particles and has a very large specific area of from some 200 to 300 square metres per gramme and can therefore absorb aromatic polycondensates and other organic compounds such as, for instance, 3,4-benzopyrene which is a well-known carcinogen. The problem of cleaning Diesel engine exhaust gases is therefore mainly one of removing the soot. It is, therefore, required to remove, from a volume of gas which is always varying and which may reach values of several cubic metres per minute, relatively tiny quantities of very small solid particles of the order of from 0.1 to 1 μ and present in an amount of from 0.1 to 1 gramme per cubic metre of exhaust gas.

Known cleaning methods for dealing with Diesel engine exhaust gases usually involve passing the gases through a fluidised bed formed by an oxidation catalyst in pellet or grain form. The cleaning apparatus for performing such methods are, therefore, effective only in catalytic conversion of the gaseous products, and they provide very little—about 5%— filtering of the soot.

Known mechanical and electrostatic methods of filtering soot have the disadvantage of not converting gas constituents whose presence is harmful and undesirable. Also, the apparatus for performing such methods cannot be used satisfactorily in mobile installations such as all kinds of vehicles where space and cost are very important, since electrostatic precipitation requires that the gases be cooled, before the electrostatic treatment, substantially to ambient temperature if the electric field is to operate satisfactorily, while the apparatus must be washed as soon as it has become filled with soot. Clearly, therefore, the apparatus for this purpose is complicated and costly. The known mechanical filters, such as sleeve or pocket or plug filters, laminated filters and box filters, also require periodic cleaning.

The present invention provides a method of filtering and purifying internal combustion engine exhaust gases containing solid particles and of progressively reducing the speed of said gases comprising passing the gases radially outwardly through a first filter of a pellet type oxidation catalyst adapted to retain the larger of said particles, and then passing the gases radially outwardly through a second filter surrounding the first filter and adapted to retain smaller sized particles.

The invention also provides apparatus for filtering and purifying internal combustion engine exhaust gases containing solid particles and for progressively reducing the

[Price 4s. 6d.]

speed of said particles, comprising a casing enclosing a first filter of a pellet type oxidation catalyst adapted to retain the larger of said particles, said first filter surrounding a passage communicating with an inlet formed in said casing, said casing further enclosing a second filter surrounding the first filter and adapted to retain smaller sized particles, such that gases entering said passage through said inlet flow radially outwardly through the first filter and then radially outwardly through the second layer before issuing through an outlet formed in said casing.

An embodiment of the apparatus according to the invention is diagrammatically illustrated by way of example in the accompanying drawings wherein:—

Fig. 1 is a side elevation at the gas entry end with part of the cover broken away; and

Fig. 2 is a sectional view taken along the line II-II of Fig. 1.

As can be seen in Fig. 2, the apparatus is formed by an exhaust vessel or casing 1 comprising a gas entry port 2 and a gas exit port 3. The gas entry port 2 is disposed in a cover 4 which is secured to the main body of the vessel 1 by screws 6 with the interposition of a gasket 5. Disposed in the vessel 1 is a hollow cylindrical member formed by two annular layers 7 and 8 separated from one another by a metal lattice wall 9 made, for instance, of rustless steel. The inner wall 10 and outer wall 11 of the cylindrical member are also made of a metal lattice. Each cylindrical wall 9, 10, 11 is formed by four parts secured to a cruciform support 12 by means of rivets 13. The support 12 therefore divides each of the two layers 7 and 8 and the space or hollow 14 into four sectors. The support 12 is secured to the cover 4 by means of screws 15 and is welded to end plate 16 of the cylindrical member. The support 12 is so secured to the cover 4—and, therefore, the cylindrical member is so secured in the vessel 1—that the hollow 14 forms an extension of the entry port 2. The cylindrical member is centred and maintained in the vessel 1 by its screws 17; the diameter and length of the cylindrical member are such that a gap 18 is left between the cylindrical member and the vessel 1 and serves for removal of the gases through the exit port 3.

The annular layer 7 of the cylindrical member is formed by alumina grains (Al_2O_3) impregnated with cobalt oxide (Co_2O_3) and of a diameter of from 1.5 to 5 mm. and so the layer 7 constitutes a pellet-type oxidation catalyst adapted to operate as a filter. The layer 8 is formed by synthetic fibres comprising 51.3% of alumina, 45.3% of silicon oxide and 3.4% of zirconium oxide and having a diameter of from 3 to 15 μ, and so forms a mechanical filter.

The apparatus hereinbefore described operates as follows:—

An exhaust pipe, for instance, of a Diesel engine, is secured to the gas entry port 2 of the apparatus, and the gases enter the space 14, whose end is closed by the end plate 16, and move radially outwards through the layers 7 and 8 and, through the lattice walls, reach the space 18 which they leave through the gas exit port 3.

The inner layer 7 has two functions—to filter soot, and to convert gaseous products by catalytic oxidation. Since the gases are travelling at a relatively high speed when they pass through the layer 7, the larger particles of soot are effectively filtered by impact. Catalysis of the gaseous products is adequate even when the catalyst is covered with soot, for the specific area of the catalyst is so great that the same can always be reached by the gases by diffusion. The layer 7 also serves to distribute the gas flow over the outer layer 8. Also, in the event of an abrupt drop in the temperature of the entering gases, the layer 7 acts as a heat regulator relatively to the layer 8 because of its thermal capacity and of its ability to evolve the heat which it has accumulated.

The layer 8 serves to filter the smaller particles of soot not retained by the layer 7. The layer 8 does this because gas speed decreases from the inside towards the outside, the apparatus being designed so that the gases can expand in the direction of their flow. The smaller soot particles are filtered by shock and by diffusion.

Regeneration of the layers 7 and 8 is automatic, the soot being burned when the engine runs on a load at which the gas temperature is above the catalytic ignition temperature of the soot—i.e. about 490°C. Since the gases are introduced inside the filter element, heat losses are low, and consequently the gas temperature may be above 490°C even at a 70% engine load.

Tests made on a lorry fitted with a 5-litre Diesel engine showed that the engine runs at above 70% of its maximum load for about 28% of the time. Should this be insufficient for regeneration of the filters, extra regeneration time must be provided by the engine being run on full load for a few minutes. The same experiments showed that the soot conversion rate is about 70%.

As will be apparent from the foregoing, the described method and apparatus provide filtering of Diesel engine exhaust gases and purification of harmful gaseous products as well as of the soot. Also, load losses are substantially constant through the various layers of the apparatus because of the progressive reduction in gas speed.

In the illustrated apparatus, the catalyst

is formed by cobalt-oxide-impregnated alumina grains or pellets, but other pellets can be used provided that they are refractory and attrition-resistant (i.e. resistant to abrasion). Aluminium silicate, zirconium oxide and the equivalent can also be used.

Similar considerations apply to the active catalyst substance used to impregnate the support. Instead of cobalt-oxides, oxides alone or mixed can be used of any other element belonging to the fourth, fifth and sixth periods of groups I, VB, VIB, VIIB and VIII of the periodic system, or the element itself can be used. For instance, the oxides of copper, of vanadium, of chromium, of manganese, of nickel, of iron and so on can be used, and so can platinum, silver and so on. Chemical compounds of the same elements can also be used, such as the carbonates and chlorides of potassium, of sodium, of copper and so on. A particularly suitable catalyst is copper-chloride-impregnated aluminium silicate.

In the example hereinbefore described, the outer filter layer 8 is formed by synthetic fibres of defined composition but they can be formed by other attrition-resistant and refractory fibrous substances. Instead of fibres being used, grains of the same kind as those forming the inner layer 7 can be used but with a smaller diameter of from 0.2 to 1.5 mm.

The cylindrical filter member can comprise more than two annular layers, with or without an outer fibrous layer. Clearly, the member can be parallelepipedic instead of cylindrical, although a parallelepipedic member takes up more space and is less efficient.

Of course, the size of the apparatus depends upon the power of the engine whose exhaust gases it is required to purify. For instance, the volume of the filter member must be about 0.05 cubic metres for a 5-litre Diesel engine. It was found by experiment that the apparatus can operate longer without regeneration in proportion as the ratio of length to diameter approaches unity. For instance, an apparatus comprising a two-layer filter member having a volume of 0.05 cubic metres, a length of 1.5 metres, and a diameter of 0.26 metres, operated for about 4 hours before regeneration became necessary; whereas an apparatus having a filter member of the same volume but 1 metre long and 0.36 metres in diameter, operated for 6 hours before regeneration was necessary.

Both apparatus were tested on a lorry having a 5-litre Diesel engine running at 50% of full load.

WHAT WE CLAIM IS:—

1. A method of filtering and purifying internal combustion engine exhaust gases containing solid particles and of progressively reducing the speed of said gases comprising passing the gases radially outwardly through a first filter of a pellet type oxidation catalyst adapted to retain the larger of said particles, and then passing the gases radially outwardly through a second filter surrounding the first filter and adapted to retain smaller sized particles.

2. A method as claimed in claim 1, further comprising passing through the filters, at least periodically, gases having a temperature above 490°C.

3. A method of filtering and purifying internal combustion engine exhaust gases containing solid particles and of progressively reducing the speed of said gases, substantially as hereinbefore described.

4. Apparatus for filtering and purifying internal combustion engine exhaust gases containing solid particles and for progressively reducing the speed of said particles, comprising a casing enclosing a first filter of a pellet type oxidation catalyst adapted to retain the larger of said particles, said first filter surrounding a passage communicating with an inlet formed in said casing, said casing further enclosing a second filter surrounding the first filter and adapted to retain smaller sized particles, such that gases entering said passage through said inlet flow radially outwardly through the first filter and then radially outwardly through the second layer before issuing through an outlet formed in said casing.

5. Apparatus for filtering and purifying internal combustion engine exhaust gases containing solid particles and for progressively reducing the speed of said particles, comprising a casing having an inlet and enclosing a hollow member secured to a casing wall, said hollow member having concentric perforate walls to define an innermost passage communicating with said inlet, a first chamber surrounding said passage and filled with a pellet type oxidation catalyst forming a first filter adapted to retain the larger of said particles, and a second chamber surrounding said first chamber and filled with material forming a second filter adapted to retain smaller sized particles, such that gases entering said passage through said inlet flow radially outwardly through the first filter and then radially outwardly through the second layer before issuing through an outlet formed in said casing.

6. Apparatus as claimed in claim 5, wherein said hollow member is cylindrical.

7. Apparatus as claimed in claim 6, wherein the perforate walls are formed of metal lattice, each wall being formed by four portions secured to a cruciform support whereby the hollow member and the interior thereof are divided into four sectors.

8. Apparatus as claimed in any one of

claims 4 to 7, wherein said catalyst is in the form of grains having a size ranging from 1.5 to 5 mm and wherein the second filter consists of catalyst in the form of grains having a size ranging from 0.2 to 1.5 mm.

9. Apparatus as claimed in any one of claims 4 to 7, wherein said catalyst is in the form of grains having a size ranging from 1.5 to 5 mm and wherein the second filter consists of attrition-resistant refractory fibres having a diameter ranging from 3 to 15 μ.

10. Apparatus as claimed in claim 8 or 9, wherein the grains forming the oxidation catalyst are of a porous and refractory substance impregnated with at least one oxide and/or a chemical compound of at least one element belonging to the fourth, fifth and sixth periods of groups I, VB, VIB, VIIB and VIII of the periodic system.

11. Apparatus as claimed in claim 10, wherein the grains are of cobalt-oxide-impregnated alumina.

12. Apparatus as claimed in claim 10, wherein the grains are of copper-chloride-impregnated aluminium silicate.

13. Apparatus as claimed in claim 9 or any one of claims 10 to 12 as appendant to claim 9, wherein the fibres are synthetic fibres comprising 51.3% of alumina, 45.3% of silicon oxide and 3.4% of zirconium oxide.

14. Apparatus for filtering and purifying internal combustion engine exhaust gases containing solid particles and for progressively reducing the speed of said particles, substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

For the Applicants,
BARLOW, GILLETT & PERCIVAL,
Chartered Patent Agents,
94 Market Street,
Manchester, 1.

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1,014498 COMPLETE SPECIFICATION
1 SHEET
This drawing is a reproduction of the Original on a reduced scale.

FIG. 1

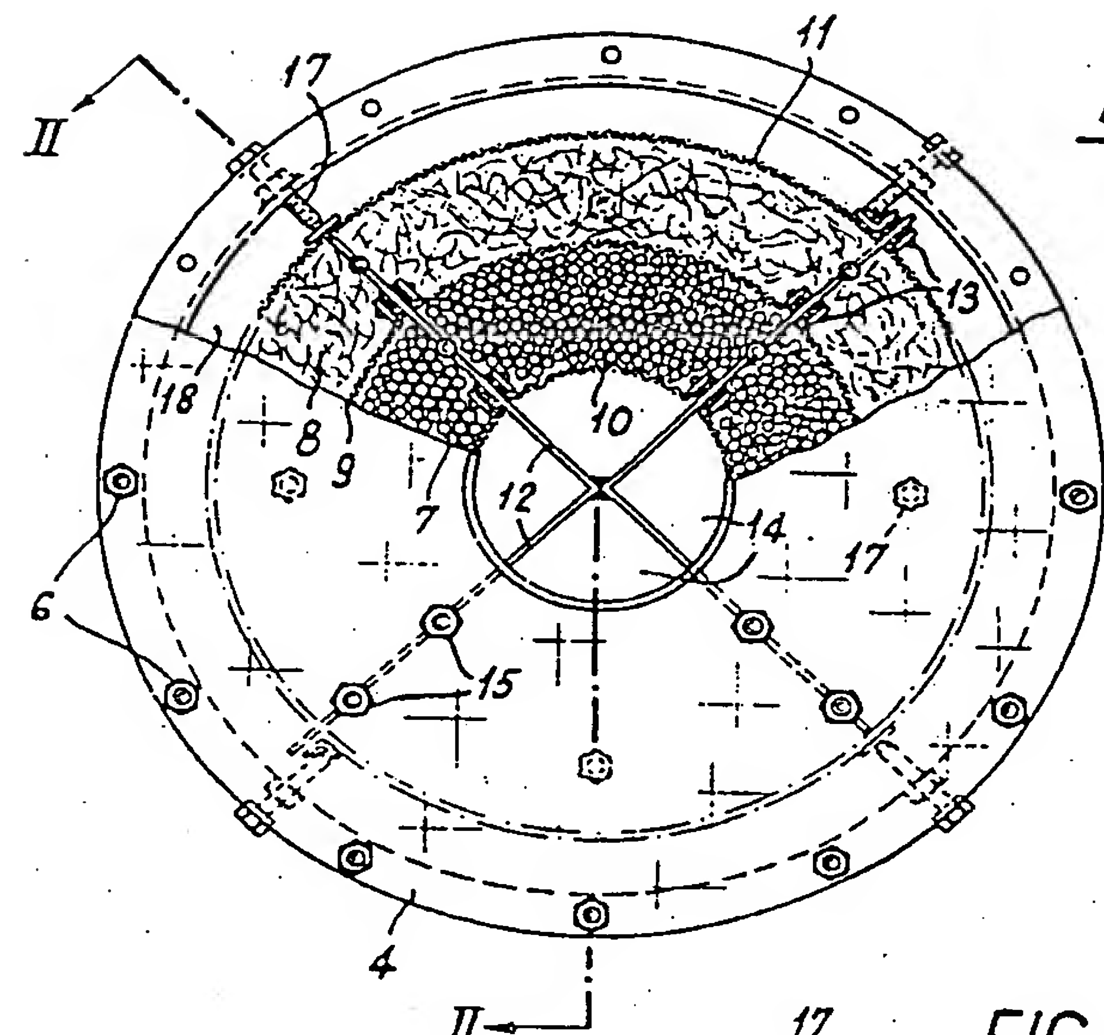

FIG. 2